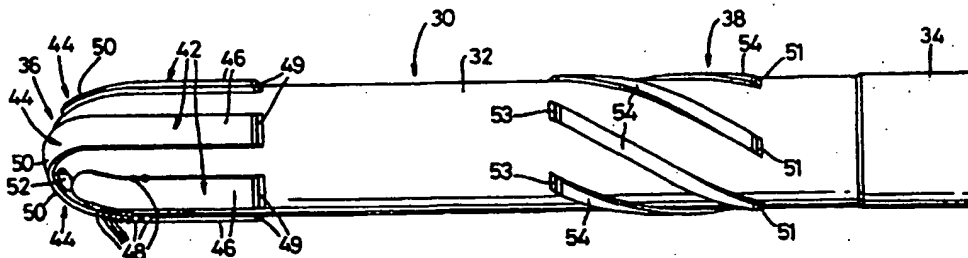




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(54) Title: IMPROVED CASING SHOE



## (57) Abstract

A casing shoe (30) for use in guiding a casing into a wellbore comprises a generally cylindrical body (32) having a box portion (34) at its rearward end for connection to a casing string and having a generally rounded nose portion (36) at its forward end. The forward end of the shoe includes cutting structures (42, 44) in the form of raised flutes extending along the sides of the cylindrical body and on the nose portion. The flutes may be provided with cutting elements such as polycrystalline diamond compact elements (48) at least at the forward ends of the flutes (42) extending along the cylindrical body. These flutes may also be configured to serve as stabilising pads, and additional stabilising pads (38) may also be provided. The nose portion may include fluid passages (50). The shoe may be adapted to be capable of being drilled through, such as by forming the nose portion from a drillable material. The provision of cutting structures on the casing shoe allows the tool to remove or negotiate obstacles which would prevent the passage of conventional casing shoes. The trailing ends of the various flutes may be provided with abrasive material to provide a back-reaming capability. The nose portion may also be eccentrically shaped to assist in negotiating obstacles.

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1     "Improved Casing Shoe"

2

3     The present invention relates to casing shoes of the  
4     type used typically in wellbores or boreholes for  
5     guiding a casing into the wellbore. The invention  
6     relates more particularly to an improved casing shoe  
7     adapted both to guide the casing into the wellbore and  
8     to perform a degree of drilling and/or reaming of the  
9     earth formation. Preferably, the casing shoe will not  
10    obstruct the passage of subsequent tools into the well.

11

12    It is known, standard practice to use casing shoes for  
13    the purpose of guiding a casing string into a wellbore.  
14    An example of a typical casing shoe 10 is illustrated  
15    in Fig. 1. When running a casing string into a  
16    wellbore, the casing string requires a leading edge  
17    capable of guiding the string since there may be  
18    partial obstructions in the wellbore, such as ledges  
19    for example. A standard casing shoe is adequate for  
20    this purpose provided that the obstructions encountered  
21    are not too severe.

22

23    The shoe shown in Fig. 1 comprises a generally  
24    cylindrical steel casing 12 having an internally  
25    threaded box portion 14 for connection to a

1 complementary pin portion of a casing string, and a  
2 central portion 16 of drillable material (such as  
3 cement, aluminium, plastics or the like) secured in the  
4 interior of the casing 12 forward of the box portion 14  
5 and having a generally rounded nose projecting  
6 frontwards beyond the forward end of the casing 12. The  
7 central portion 16 has a through-bore 18 to allow the  
8 passage of fluids. A shoe of this type may incorporate  
9 other, associated equipment, such as a unidirectional  
10 ball-valve (not shown) in the bore 18, which inhibits  
11 flow of mud from the wellbore into the casing string  
12 whilst running the casing, but allows flow of cement  
13 from the bore of the casing string into the annulus  
14 between the casing string and the wellbore after the  
15 full length of the casing string has been run into the  
16 wellbore. The present invention may also incorporate  
17 such additional, associated equipment.

18

19 An important feature of most casing shoes is that the  
20 central portion 16 is drillable by standard oilfield  
21 drill bits, since it may subsequently be necessary to  
22 drill a further section of wellbore beyond the casing  
23 shoe. However, there is also a requirement for casing  
24 shoes which are not capable of being drilled through.

25

26 The advent in recent years of highly deviated or  
27 horizontal wells in the oil industry has increased both  
28 the frequency and seriousness of difficulties  
29 encountered while running wellbore casing strings, to  
30 the extent where a conventional casing shoe may be  
31 unable to pass a particular obstruction in the  
32 wellbore. Obstructions may arise from the bore of the  
33 well itself swelling inwardly, as is sometimes the case  
34 with hydratable shales for example, or when the  
35 wellbore contains ledges caused by drilling through  
36 rock formations of differing hardnesses, or due to the

1 accumulation of loose material in the wellbore being  
2 ploughed up ahead of the casing shoe until further  
3 progress is no longer possible.

4  
5 This last situation is illustrated in Fig. 2, which  
6 shows the casing shoe 10 of Fig. 1 attached to a casing  
7 string 20 being run in a near-horizontal wellbore 22  
8 surrounded by competent formation 24. The passage of  
9 the casing shoe 10 along the wellbore 22 is obstructed  
10 by an unconsolidated formation 26 of loose material.

11  
12 The consequence of encountering such difficulties are,  
13 at best, delays in the schedule of the well programme  
14 and, at worst, having to drill all or part of the well  
15 again. In any case, significant additional cost is  
16 involved.

17  
18 It is an object of the present invention to provide an  
19 improved casing shoe which performs the string-guiding  
20 function of standard casing shoes, but which is capable  
21 of clearing obstructions which would halt the passage  
22 of conventional shoes. In the preferred embodiments of  
23 the invention, this involves the ability to ream  
24 swelled sub-surface formations and/or to deal with  
25 large quantities of unconsolidated solids, whilst  
26 (preferably) allowing the subsequent passage of other  
27 equipment.

28  
29 In accordance with the present invention there is  
30 provided a casing shoe comprising a generally  
31 cylindrical body having a first end adapted for  
32 connection to a casing string and having a second end  
33 including a generally rounded nose portion, said casing  
34 shoe further including cutting means adapted to ream,  
35 drill, cut or displace obstacles encountered in use of  
36 the casing shoe in a borehole.

1 Preferably, said cutting means includes cutting  
2 structures disposed along the sides of said generally  
3 cylindrical body and on said nose portion.

4  
5 Preferably also, said cutting structures comprise a  
6 plurality of raised flutes extending along at least a  
7 portion of said cylindrical body and converging towards  
8 the forward end of said nose portion.

9  
10 Preferably also, said flutes are provided with cutting  
11 elements such as polycrystalline diamond compact (PDC)  
12 elements.

13  
14 Preferably also, said cutting elements are located at  
15 least on those portions of said flutes extending along  
16 said cylindrical body adjacent said nose portion.

17  
18 Preferably, rearward portions of said flutes extending  
19 along the sides of said cylindrical body are configured  
20 as stabilising pads.

21  
22 Preferably also, the outer faces of said rearward  
23 portions are provided with hard facing of tungsten  
24 carbide or the like, and the trailing ends of said  
25 rearward portions are provided with abrasive material,  
26 such as aggressive tungsten carbide, to enable a degree  
27 of back-reaming.

28  
29 Preferably also, those portions of said flutes located  
30 on said nose portion include cutting elements such as  
31 tungsten carbide discs, shaped ceramics or angular  
32 aggregate.

33  
34 In one preferred embodiment, said cutting structures  
35 include primary cutting structures including first  
36 raised flutes extending along at least a portion of

1 said cylindrical body and terminating at said second  
2 end thereof.

3

4 Preferably also, the forward ends of said cylindrical  
5 body and of said first flutes taper inwardly to the  
6 inner diameter of said cylindrical body, and said  
7 forward ends of said first flutes include cutting  
8 elements such as polycrystalline diamond compact (PDC)  
9 elements.

10

11 Preferably, said cutting structures also include  
12 secondary cutting structures located on said rounded  
13 nose portion said secondary cutting structures  
14 comprising extensions of said first flutes extending  
15 from the ends of said first flutes towards the centre  
16 of said nose portion.

17

18 In certain embodiments, at least a portion of the  
19 interior bore of said cylindrical body adjacent said  
20 second end contains an inner portion of drillable  
21 material secured thereto, said rounded nose of the  
22 casing shoe being formed by said inner portion  
23 projecting beyond said second end of said cylindrical  
24 body.

25

26 Preferably, said flute extensions of said secondary  
27 cutting structures are formed integrally with said  
28 rounded nose from the material of said inner portion.

29

30 The following features are preferably included in all  
31 embodiments of the invention:

32

33 said nose portion may have at least one through  
34 bore formed therein to communicate with the interior of  
35 said cylindrical body;

36

1           the casing shoe may further include stabilising  
2 means, suitably comprising a plurality of spiral  
3 flutes, which may be formed integrally with the  
4 cylindrical body of the casing shoe, or may be provided  
5 on a separate cylindrical body adapted to be connected  
6 between the casing shoe and a casing string; the outer  
7 faces of said spiral flutes are preferably provided  
8 with hard facing of tungsten carbide or the like, and  
9 the trailing ends of said spiral flutes are provided  
10 with abrasive material, such as aggressive tungsten  
11 carbide, to enable a degree of back-reaming; the  
12 forward ends of said spiral flutes are preferably  
13 provided with abrasive material, such as aggressive  
14 tungsten carbide, to protect the flutes from damage  
15 during forward motion of the shoe.

16  
17 Where the shoe is required to be capable of being  
18 drilled through, the rounded nose portion may be formed  
19 as a hollow structure capable of being drilled through,  
20 deformed or displaced if required to enable subsequent  
21 drilling operations.

22  
23 In a further variation of the invention, the rounded  
24 nose portion may be eccentrically shaped to assist in  
25 negotiating obstructions.

26  
27 Embodiments of the invention will now be described, by  
28 way of example only, with reference to the  
29 accompanying drawings in which:

30  
31           Fig. 1 is a sectional side view of a conventional  
32 casing shoe;

33  
34           Fig. 2 is a sectional side view of the casing shoe  
35 of Fig. 1 approaching an obstruction in a  
36 wellbore;



1        Fig. 3 is a side view of an example of a casing  
2        shoe embodying the present invention;

3  
4        Fig. 4 is a sectional side view of the casing shoe  
5        of Fig. 3;

6  
7        Fig. 5 is a front end view of the casing shoe of  
8        Figs. 3 and 4;

9  
10       Fig. 6 is a side view of a further example of a  
11       casing shoe embodying the present invention; and

12  
13       Fig. 7 is a front end view of the casing shoe of  
14       Fig. 6.

15  
16  
17       Referring now to the drawings, Figs. 3 and 4 show an  
18       example of a casing shoe 30 in accordance with the  
19       invention.

20  
21       The shoe 30 comprises a generally cylindrical steel  
22       casing 32 having an internally threaded box portion 34  
23       at its tail end, for connection to a casing string (not  
24       shown), and having a generally rounded nose portion 36  
25       at its front end, as shall be described in greater  
26       detail below. Optionally, the shoe 30 may also include  
27       a stabiliser portion 38, as shall also be discussed in  
28       greater detail below.

29  
30       In this embodiment, the shoe 30 also includes a central  
31       portion 40 of drillable material, the forward end of  
32       which forms the rounded nose 36. This portion may be  
33       of cement, aluminium, plastics or the like. The type  
34       of material from which it is formed may depend upon the  
35       type of drill bit which will be required to drill it  
36       out, should this prove necessary.

1 In accordance with the invention, the forward end of  
2 the shoe 30 is provided with cutting structures which  
3 enable the tool to ream, drill, cut or displace  
4 obstacles such as inward swellings of the competent  
5 formation and/or accumulations of unconsolidated  
6 solids. In this example, the shoe 30 includes primary  
7 cutting structures extending along the sides of the  
8 forward end of the shoe and intended primarily for  
9 reaming inward swellings of the formation, and  
10 secondary cutting structures, generally designated by  
11 the numeral 44, incorporated in the rounded nose 36 and  
12 intended primarily for the displacement of  
13 unconsolidated solids.

14  
15 The primary cutting structures comprise a plurality of  
16 linear flutes 42 extending substantially parallel to  
17 one another to the forward end of the casing 32 and  
18 spaced equidistantly around the circumference thereof,  
19 and having suitable cutting elements, such as  
20 polycrystalline diamond compact (PDC) elements, set  
21 into their lateral edges, as indicated at 48. As seen  
22 in Fig. 4, the walls of the casing 32 are tapered  
23 inwardly towards the forward end thereof and the  
24 forward ends of the flutes 42 follow the tapered  
25 contour of the casing walls and terminate at the inner  
26 diameter of the casing 32. The PDC's 48 are located  
27 along the tapered forward portions of the flutes 42.  
28 The rearward portions 46 of the flutes 42 extending  
29 along the sides of the casing 32 are configured as  
30 stabilising pads and may be provided with hard facings  
31 of material such as tungsten carbide. The trailing ends  
32 of the flutes 46 may also be provided with abrasive  
33 elements 49 of material such as aggressive tungsten  
34 carbide, providing a back-reaming capability.

35

36 The secondary cutting structures 44 comprise contiguous

1 extensions 50 of the flutes 42, formed integrally with  
2 the drillable material of the central portion 40 and  
3 extending towards the centre of the rounded nose 36.  
4 The configuration of the secondary cutting structures  
5 44 is more clearly seen in Fig. 5. In this example  
6 there are six primary flutes 42 and six corresponding  
7 extensions 50, of which alternate extensions are  
8 designated 50a in Fig. 5 and intervening extensions are  
9 designated 50b. The alternate flute extensions 50a  
10 converge at the centre of the nose 36, and the  
11 intervening flute extensions 50b terminate outwardly of  
12 the centre. Depending upon the type of obstructions  
13 expected to be encountered by the secondary cutting  
14 structures 44, cutting elements (not shown) such as  
15 tungsten carbide discs, shaped ceramics or angular  
16 aggregate might be incorporated therein, or cutting  
17 might be performed by the flute extensions 50  
18 themselves. Where the casing shoe is adapted to be  
19 capable of being drilled through, as in this example,  
20 it may be preferable to omit hard cutting elements from  
21 the drillable portion of the nose, since such elements  
22 may interfere with the drilling through of the tool.

23  
24 One or more through bores 52 may be formed in the  
25 central portion 40, to allow the passage of drilling  
26 fluids, cement etc from the interior of the casing  
27 string to the external annulus as may be required in  
28 use of the shoe. In particular, the bores 52 allow the  
29 passage of drilling fluid to flush away debris created  
30 by the cutting action of the tool. The spaces between  
31 the flutes 42, 50 of the primary and secondary cutting  
32 structures also serve as fluid passages for fluid  
33 between the tool face and the annulus between the  
34 casing string and the borehole. In this example, there  
35 are three bores 52, the forward ends of which are  
36 disposed between the ends of the intervening flute

1 extensions 50b and the centre of the nose 36. If  
2 required, the bores 52 may be fitted with valves etc  
3 (not shown) as in prior art casing shoes.

4  
5 The optional stabiliser portion 38 may be used to  
6 provide a particular directional response from the tool  
7 or to act as a pivot point to assist the tool in  
8 negotiating obstacles. In this example, the stabiliser  
9 comprises a plurality of spiral flutes 54, formed  
10 integrally with the casing 32. Alternatively, the  
11 stabiliser could be provided as a separate component  
12 (not shown), having its own threaded box and pin, which  
13 can be connected between the shoe 30 and the casing  
14 string. In this case the shoe itself could be  
15 substantially shorter in length than the illustrated  
16 example with its integral stabiliser 38.

17  
18 The outer faces of said spiral flutes 38 may also be  
19 provided with hard facing of tungsten carbide or the  
20 like, as with the forward stabiliser pads 46, and their  
21 trailing ends may also be provided with abrasive elements  
22 51, such as aggressive tungsten carbide, to assist  
23 back-reaming. The forward ends of the spiral flutes 38  
24 may similarly be provided with abrasive elements 53, to  
25 protect the flutes 38 from damage during forward motion  
26 of the shoe 30.

27  
28 In a variation of this drillable embodiment of the  
29 invention, the inner portion 40 might be omitted and  
30 the rounded nose formed as a hollow structure designed  
31 to be capable of being drilled through or displaced  
32 forwardly and outwardly into a region defined  
33 approximately by forward extension of the casing 32.  
34 Such displacement would take place after the casing  
35 string has been run to its full depth and before it has  
36 been cemented in place. The displacement might suitably

1 take place as an integral part of the cementing  
2 procedure. A hollow nose of this type might suitably  
3 take the form of a segmented dome structure which is  
4 plastically deformable in response to hydraulic  
5 pressure associated with the injection of cement.  
6 Alternatively, the dome segments might be hinged to the  
7 forward end of the tubular casing 32. In either case,  
8 the nose structure may include ribs or the like  
9 providing the secondary cutting structures.

10  
11 In a further variation, the nose portion of the tool  
12 may be eccentrically shaped so as to impart a cyclic  
13 lateral motion upon encountering an obstruction. This  
14 may assist in negotiating such obstructions. Figs. 6  
15 and 7 of the drawings show an example of a casing shoe  
16 60 in accordance with the invention, having an  
17 eccentrically shaped nose portion 62 of this type. The  
18 cutting structures in this example comprise three  
19 spiral flutes 64, 66, 68, converging at the forward end  
20 of the nose portion 62. The flutes may be provided  
21 with cutting elements (not shown) such as PDC cutters,  
22 as required, and the shoe may include fluid passages,  
23 having outlets 70, 72, 74 in the nose portion 62, as in  
24 the previous embodiment.

25  
26 The embodiment of Figs. 6 and 7 is also an example of a  
27 "non-drillable" shoe; i.e. it does not include any  
28 portion purposely designed to be capable of being  
29 drilled through. The shoe has an internal blind bore  
30 76, which terminates around the point where the  
31 generally cylindrical body of the shoe begins to taper  
32 to form the nose portion 62. Accordingly, the nose  
33 portion 62 is solid, except for the fluid channels (not  
34 shown) extending therethrough.

35  
36 It will be appreciated that this embodiment could be

1 made to be drillable in a similar manner as the  
2 previous embodiment and that, conversely, the drillable  
3 embodiment of Figs. 3 - 5 could be made non-drillable  
4 in the same way as that of Figs. 6 and 7. Also, the  
5 embodiment of Figs. 6 and 7 could be modified to  
6 incorporate an integral stabiliser portion, if  
7 required. In non-drillable embodiments of the  
8 invention, hard cutting elements may be located  
9 anywhere on the nose portion as required.

10

11 The provision of cutting structures on the casing shoe  
12 allows the tool to remove or negotiate obstacles which  
13 would prevent the passage of conventional casing shoes.  
14 Other features such as the stabiliser also assist in  
15 the negotiation of obstacles.

16

17 Improvements or modifications may be incorporated  
18 without departing from the scope of the invention.

19

20

21

1     Claims

2

3     1.    A casing shoe comprising a generally cylindrical  
4     body having a first end adapted for connection to a  
5     casing string and having a second end including a  
6     generally rounded nose portion, said casing shoe  
7     further including cutting means adapted to ream, drill,  
8     cut or displace obstacles encountered in use of the  
9     casing shoe in a borehole.

10

11    2.    A casing shoe as claimed in Claim 1, wherein said  
12    cutting means includes cutting structures disposed  
13    along the sides of said generally cylindrical body and  
14    on said nose portion.

15

16    3.    A casing shoe as claimed in Claim 2, wherein said  
17    cutting structures comprise a plurality of raised  
18    flutes extending along at least a portion of said  
19    cylindrical body and converging towards the forward end  
20    of said nose portion.

21

22    4.    A casing shoe as claimed in Claim 3, wherein said  
23    flutes are provided with cutting elements such as  
24    polycrystalline diamond compact (PDC) elements.

25

26    5.    A casing shoe as claimed in Claim 4, wherein said  
27    cutting elements are located at least on those portions  
28    of said flutes extending along said cylindrical body  
29    adjacent said nose portion.

30

31    6.    A casing shoe as claimed in any of Claims 3 to 5,  
32    wherein rearward portions of said flutes extending  
33    along the sides of said cylindrical body are configured  
34    as stabilising pads.

35

36    7.    A casing shoe as claimed in Claim 6, wherein the

1 outer faces of said rearward portions are provided with  
2 hard facing of tungsten carbide or the like, and the  
3 trailing ends of said rearward portions are provided  
4 with abrasive material, such as aggressive tungsten  
5 carbide, to enable a degree of back-reaming.  
6

7 9. A casing shoe as claimed in any one of Claims 3  
8 to 7, wherein those portions of said flutes located on  
9 said nose portion include cutting elements such as  
10 tungsten carbide discs, shaped ceramics or angular  
11 aggregate.  
12

13 10. A casing shoe as claimed in any one of Claims 3 to  
14 9, wherein said cutting structures include primary  
15 cutting structures including first raised flutes  
16 extending along at least a portion of said cylindrical  
17 body and terminating at said second end thereof.  
18

19 11. A casing shoe as claimed in Claim 10, wherein the  
20 forward ends of said cylindrical body and of said first  
21 flutes taper inwardly to the inner diameter of said  
22 cylindrical body, and said forward ends of said first  
23 flutes include cutting elements such as polycrystalline  
24 diamond compact (PDC) elements.  
25

26 12. A casing shoe as claimed in Claim 10 or Claim 11,  
27 wherein said cutting structures also include secondary  
28 cutting structures located on said rounded nose portion  
29 said secondary cutting structures comprising extensions  
30 of said first flutes extending from the ends of said  
31 first flutes towards the centre of said nose portion.  
32

33 13. A casing shoe as claimed in any preceding Claim,  
34 wherein at least a portion of the interior bore of said  
35 cylindrical body adjacent said second end contains an  
36 inner portion of drillable material secured thereto,



1 said rounded nose of the casing shoe being formed by  
2 said inner portion projecting beyond said second end of  
3 said cylindrical body.

4  
5 14. A casing shoe as claimed in Claim 13 when  
6 dependent from Claim 12, wherein said flute extensions  
7 of said secondary cutting structures are formed  
8 integrally with said rounded nose from the material of  
9 said inner portion.

10  
11 15. A casing shoe as claimed in any preceding Claim,  
12 wherein said nose portion has at least one through bore  
13 formed therein to communicate with the interior of said  
14 cylindrical body.

15  
16 16. A casing shoe as claimed in any preceding Claim,  
17 further including stabilising means.

18  
19 17. A casing shoe as claimed in Claim 16, wherein said  
20 stabilising means comprises a plurality of spiral  
21 flutes.

22  
23 18. A casing shoe as claimed in Claim 17, wherein said  
24 spiral flutes are formed integrally with the  
25 cylindrical body of the casing shoe.

26  
27 19. A casing shoe as claimed in Claim 17, wherein said  
28 spiral flutes are provided on a separate cylindrical  
29 body adapted to be connected between the casing shoe  
30 and a casing string.

31  
32 20. A casing shoe as claimed in any one of Claims 17  
33 to 19, wherein the outer faces of said spiral flutes  
34 are provided with hard facing of tungsten carbide or  
35 the like, and the trailing ends of said spiral flutes  
36 are provided with abrasive material, such as aggressive

1 tungsten carbide, to enable a degree of back-reaming.

2

3 21. A casing shoe as claimed in any one of Claims 17  
4 to 20, wherein the forward ends of said spiral flutes  
5 are provided with abrasive material, such as aggressive  
6 tungsten carbide, to protect the flutes from damage  
7 during forward motion of the shoe.

8

9 22. A casing shoe as claimed in any preceding Claim,  
10 wherein said rounded nose portion is formed as a hollow  
11 structure capable of being drilled through, deformed or  
12 displaced if required to enable subsequent drilling  
13 operations.

14

15 23. A casing shoe as claimed in any preceding Claim,  
16 wherein said rounded nose portion is eccentrically  
17 shaped to assist in negotiating obstructions.

18

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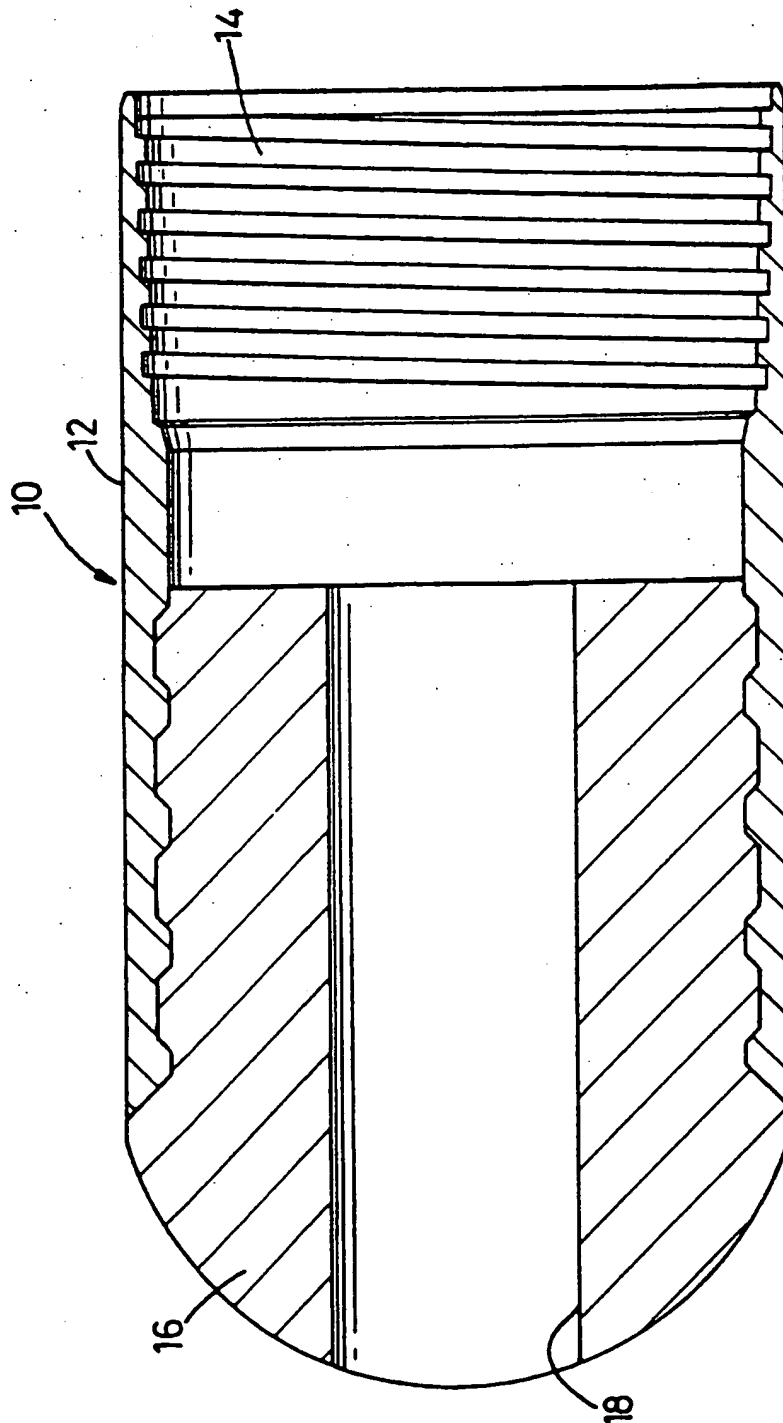


Fig. 1  
(PRIOR ART)

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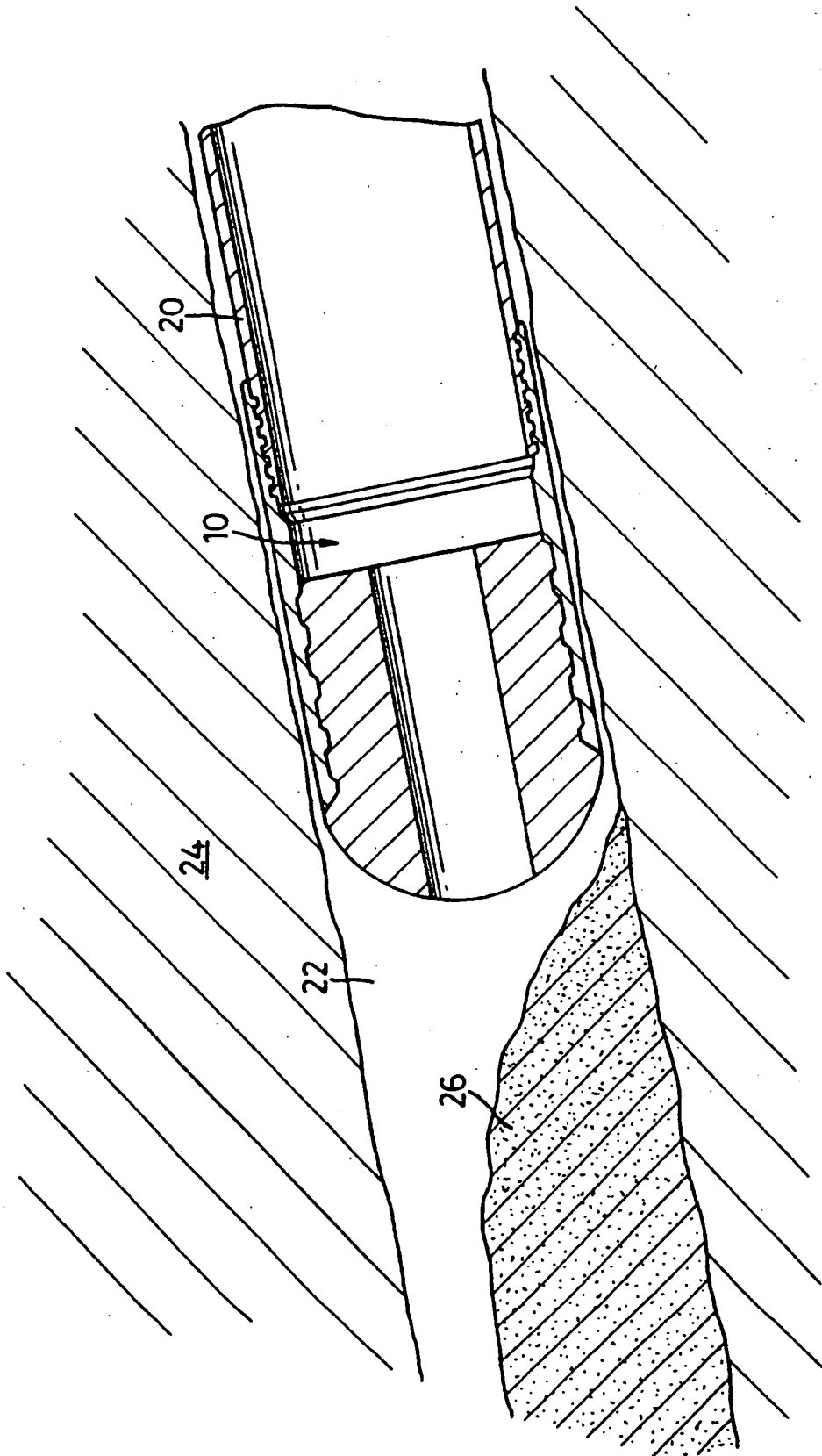


Fig. 2

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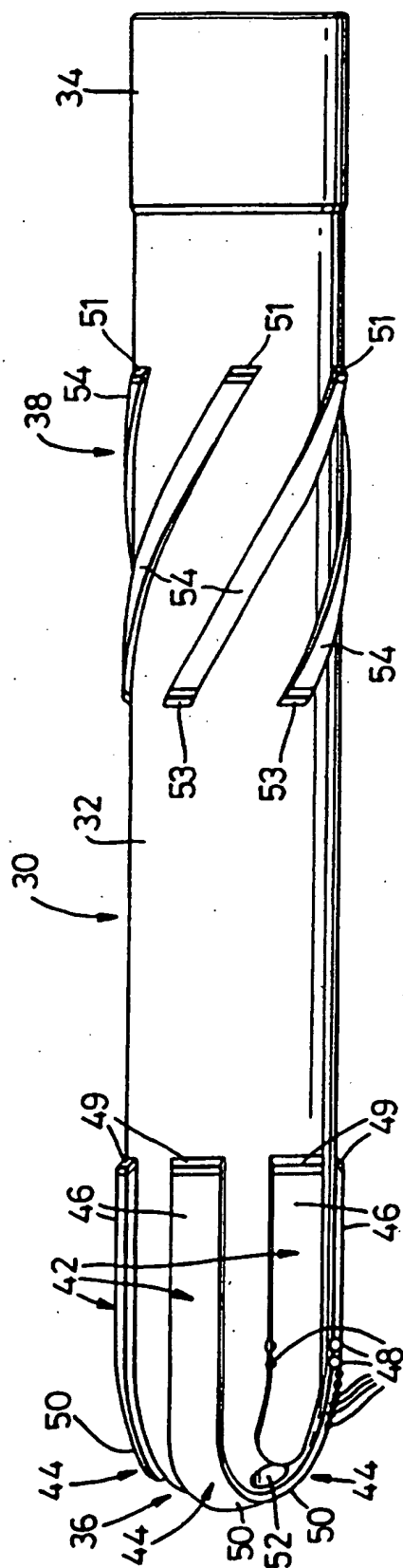


Fig. 3

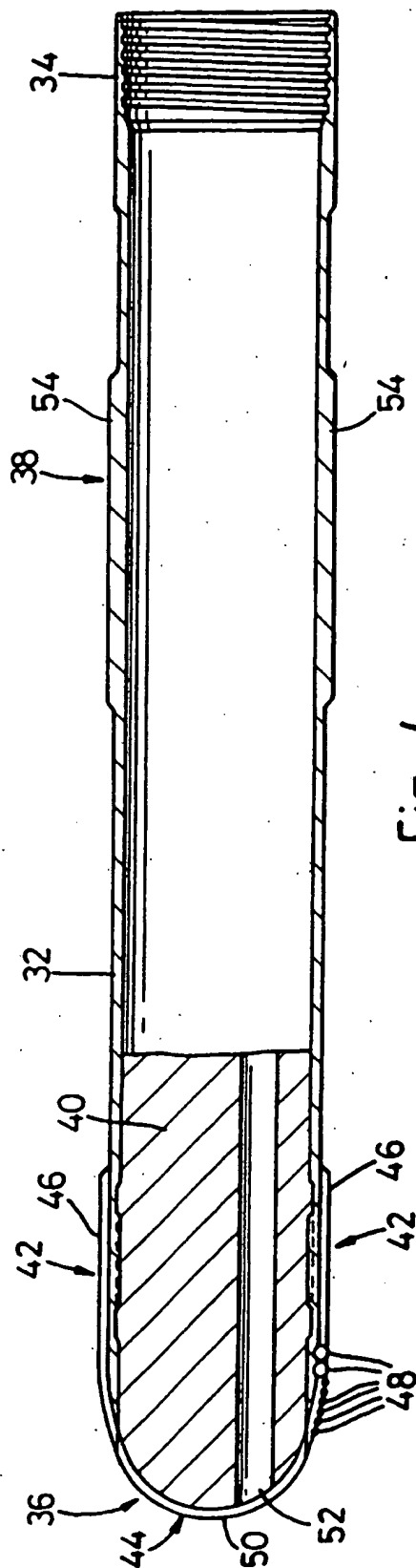


Fig. 4

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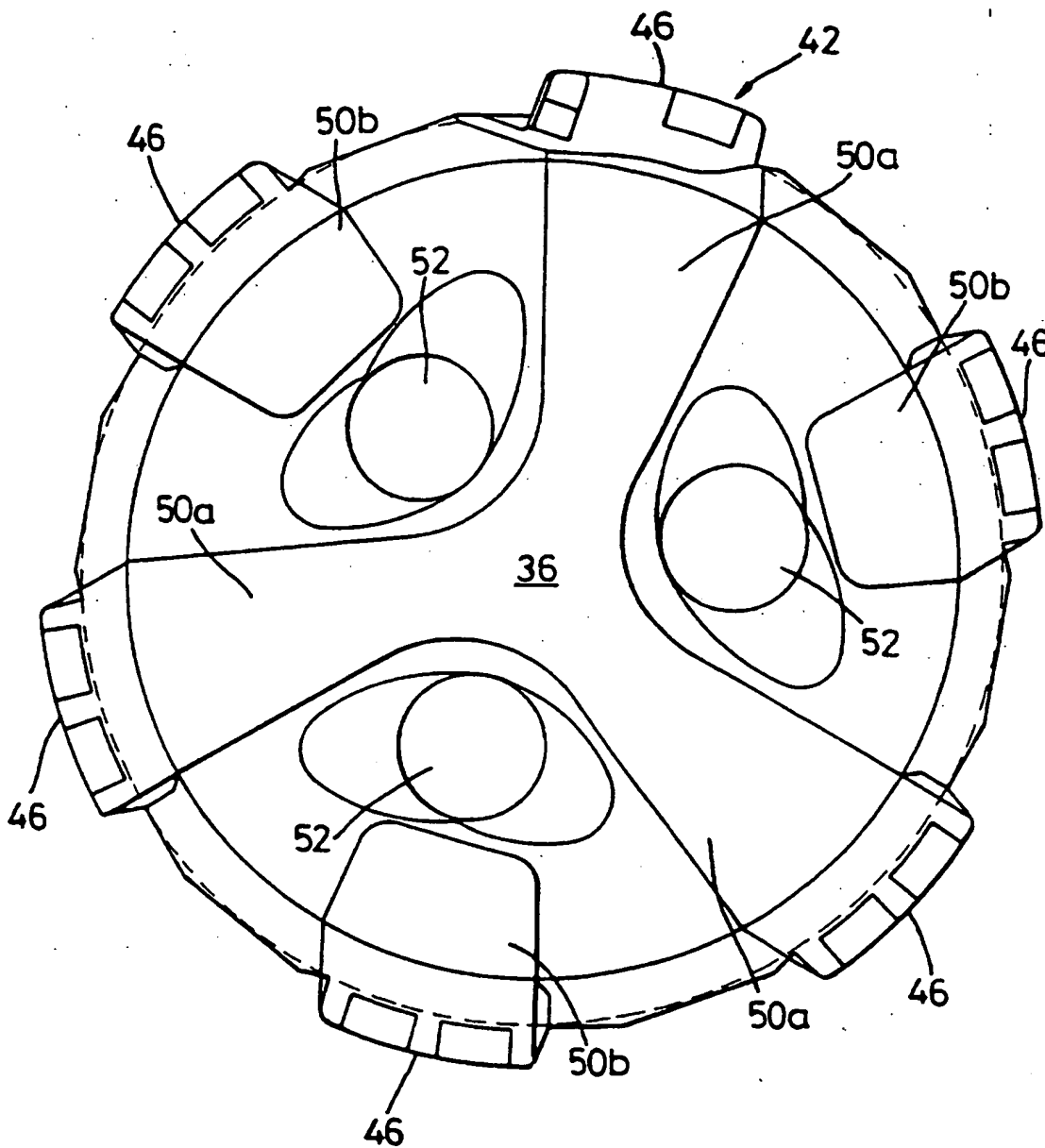


Fig. 5

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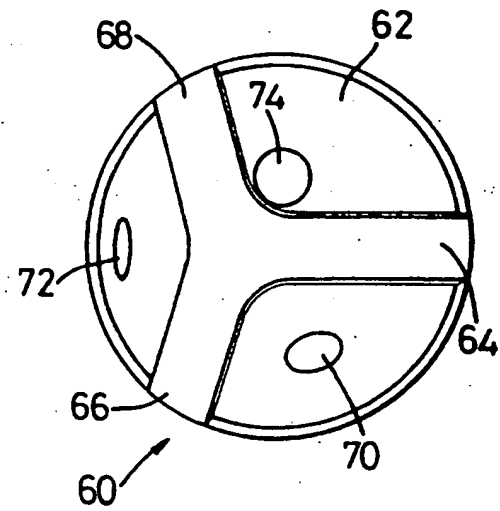
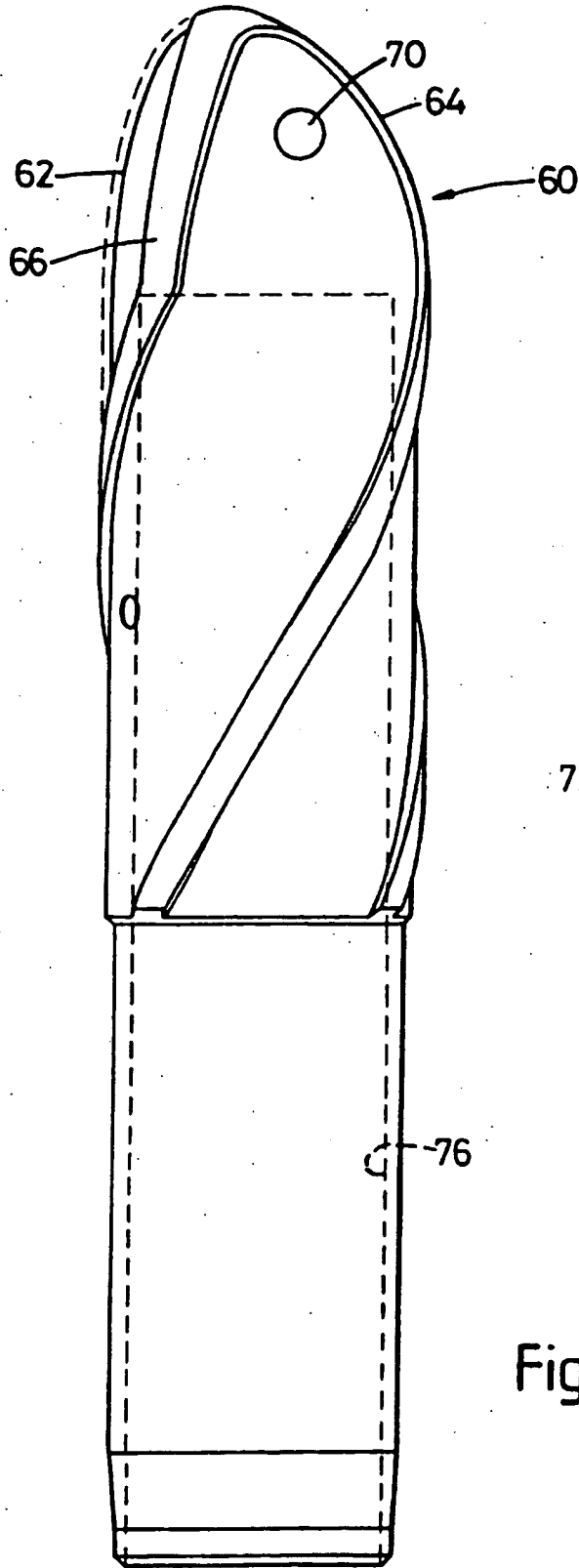


Fig. 7

Fig. 6

## INTERNATIONAL SEARCH REPORT

Inter national Application No

PCT/GB 96/00556

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 E21B17/14 E21B17/10

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No.                  |
|------------|--|--|
| X<br>Y     | US,A,2 334 788 (O'LEARY) 23 November 1943<br>see page 1, left-hand column, line 32 -<br>line 42; figures<br><br>see page 2, right-hand column, line 74 -<br>page 3, left-hand column, line 34<br>--- | 1,15,22<br>2,13,<br>16-18,<br>20,21,23 |
| Y          | CA,A,1 222 448 (BRALORNE RESOURCES LTD) 2<br>June 1987<br>see claim 1; figures<br>---  | 2                                      |
| Y          | GB,A,2 170 528 (SEABOURN) 6 August 1986<br>see abstract; figures<br>---  | 13                                     |
| Y          | US,A,5 289 889 (GEARHART) 1 March 1994<br>see abstract; figures<br>---   | 16-18,<br>20,21                        |
|            | ---<br>-/--  |  |

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

2 July 1996

Date of mailing of the international search report

15. 07. 96

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## INTERNATIONAL SEARCH REPORT

International Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages    | Relevant to claim No. |
|------------|---|-----------------------|
| Y          | WO,A,93 25794 (PANTHER OIL TOOLS) 23<br>December 1993<br>see abstract; figures<br>--- | 20                    |
| Y          | US,A,4 618 010 (FALGOUT) 21 October 1986<br>see abstract; figures<br>---              | 21                    |
| Y          | US,A,3 266 577 (TURNER) 16 August 1966<br>see claim 1; figures<br>---                 | 23                    |
| A          | EP,A,0 028 121 (FLETCHER) 6 May 1981<br>see abstract; figures<br>-----                | 1                     |

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Int. Application No  
PCT/GB 96/00556

| Patent document<br>cited in search-report | Publication<br>date | Patent family<br>member(s)      | Publication<br>date  |
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| CA-A-1222448                              | 02-06-87            | NONE                            |                      |
| GB-A-2170528                              | 06-08-86            | NONE                            |                      |
| US-A-5289889                              | 01-03-94            | NONE                            |                      |
| WO-A-9325794                              | 23-12-93            | AU-B- 4342493                   | 04-01-94             |
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| US-A-3266577                              | 16-08-66            | NONE                            |                      |
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